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Rapid Prototyping Applications in Various Field of Engineering and Technology

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***Abstract*—**In the product design and development process, the prototyping or model making is one of the important step to finalize a product which helps in conceptualization of a design. Rapid Prototyping (RP) is layer-by-layer material deposition started during early 1980s with the enormous growth in Computer Aided Design and Manufacturing (CAD/CAM) technologies. The edges and surfaces of a complex solid model and their information are used for defining a product which is further manufactured as a finished product by CNC machining. This paper provides a better platform for researchers, new learners and product manufacturers for various applications of RP models. Subsequently it creates awareness among the peoples of recently developing RP method of manufacturing in product design, developments and its applications.

***Keywords*—**Prototyping, layer-by-layer, CAD/CAM, product design.

I. Introduction

RAPID PROTOTYPING (RP) is defined as a group of technologies used to quickly produce a scale model of a component or group of components using 3-dimensional computer aided design (CAD) data. Due to the worldwide competition of the product the manufacturing industries has given more important in the product development phase. Therefore the RP and manufacturing techniques plays the vital role in a product development. It has been high prospective to reduce the cycle and cost of product development. It is an important tool in digital manufacturing in rapid product development. There are a variety of methods that can be used in RP to deposit the material for creating a proto model through RP technique. The some of the important methods are used in industries for manufacturing the product model such as Stereolithography (SLA), Selective Layer Sintering (SLS), 3D Printing (3DP), Fused Deposition Modelling (FDM).

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II. Literature Review

The many papers has been published in the rapid prototyping and tooling techniques in a particular product development. The literature has been made in the view of methods, products and development of products in various applications. In [1]-[3] Rapid Prototyping (RP) is a new forming process which fabricates physical parts layer by layer under computer control directly from 3D CAD models in a very short time. In contrast to traditional machining methods, the majority of rapid prototyping systems tend to fabricate parts based on additive manufacturing process, rather than subtraction or removal of material. Therefore, this type of fabrication is unconstrained by the limitations attributed to conventional machining approaches. In [1], [3], [4] from the emergence of the first RP system in 1988, RP technology has been introduced successfully in the industries of automotives, aerospace, electronics, toy and so on. The RP methods commercially available include Stereo Lithography (SL), Selective Laser Sintering (SLS), Fused Deposition Manufacturing (FDM), Laminated Object Manufacturing (LOM), Ballistic Particle Manufacturing (BMP), and Three-Dimensional Printing (3D printing). In [5] reported that in the manufacturing industry is evolving toward digitalization, network and globalization. With the fast advance and extensive usage of the Internet technologies, they have been widely employed in developing manufacturing systems to associate various product development activities, such as marketing, design, process planning, production, customer service, etc., distributed at different locations into an integrated environment. In [6] developed a tele-service system for RP service bureaus to support the implementation of the Web-based RP manufacturing. In [7] introduced the development of a distributed rapid prototyping system via the Internet to form a framework of Internet prototyping and manufacturing for the support of effective product development. The proposed methodology is targeted at a wide audience using a disparate range of computer systems to access remotely located rapid prototyping facilities via the Internet for prototype fabrication. The methodology is useful for both educational research for teaching evolving rapid prototyping technologies and remote scientific visualization. This approach is based on the merger of object-oriented modular software architecture and client server communications for the remote control of rapid prototyping hardware (called fused deposition modeling) via the Internet. Other Web tools are used to allow the remote user to have higher interactivity with the server applications that have a direct link with the front-end terminals controlling the rapid

prototyping hardware. In [8] recently developed a remotely accessible laboratory for rapid prototyping. The objective of this project is to develop and disseminate a Remotely Accessible Rapid Prototyping (RRP) Laboratory at Tennessee Technological University (TTU). In [9] introduced a RP design advice system that can recommend the most appropriate route to creating a physical prototype. In [10] reported on the use of inkjet printing to fabricate neuron-adhesive patterns such as islands and other shapes using poly(ethylene) glycol (PEG) as cell-repulsive material and a collagen/poly-D-lysine (PDL) mixture as cell-adhesive material. They worked with a positive relief: PEG used as background and anti-fouling material was bonded covalently to the glass surface while the collagen/PDL mixture was used as the printed foreground and cell-adhesive material. They also suggest that the inkjet printing technique could be extrapolated to building 3D structures in a layer-by-layer fashion. In [11] reviewed the functionally graded material processing methods has become a subject of research in the material science, composites, and ceramic engineering and metallurgy communities. In [12] studied in processing of polymer composites by SLS method. SLS can fabricate such heterogeneous objects. The material deposited can be varied continuously to yield a functionally graded material object with varying material distribution. In [13] found micro-pores formed within the scaffold structure produced via SLS from physically blended Hydroxyapatite (HA)/polyetheretherketone and HA/polyvinyl alcohol composites. In [14] presented the porosity also offers an opportunity during post-processing to introduce additional materials into the object to alter material composition as well as help to control part stability. Polymethyl methacrylate coated calcium phosphate powders have been successfully processed via SLS and subsequent post-processing enables to produce strong porous structures. In [15] reviewed that the RP techniques is the best method for fabrication of tissue scaffolds compared with conventional method and the current limitations and future trends of scaffold fabrication are discussed. In [16] the testing of materials for rapid prototyping has discussed in FDM technology. Most of the RP parts are finished or touched up before they are used for their intended applications. In [17] the orthodontic applications of RP models are discussed. Lengthy orthodontic treatment usually not accepted by the patients because the patient compliance is lost. Patient's compliance can be improved by facilitating faster tooth movements by designing a localized dental vibrator using advanced engineering principles.

III. Objective of This Study

The main objective of this paper is to create awareness about the product developments and manufacturing the models with the aid of computer modeling among the industrial peoples, researchers, students community, and also the application of RP model developments in various fields. This paper reveals that the challenges associate insight in Rapid Prototyping and the factors to be considered while developing Rapid Prototyping techniques in Indian scenario.

IV. Applications of Rapid Prototyping Model

This paper provides the application of RP models in various field like medical, textile, electrical appliances, foot-ware design, architectural interior design and furniture design etc.

A. Medical Application

The RP model plays the vital role in medical applications. It is used in human facial scull transparency in the medical field. Fig. 1 shows the damaged portion of the human facial scull. Fig. 2 shows the damaged portion of the facial scull has been replaced by the RP model.

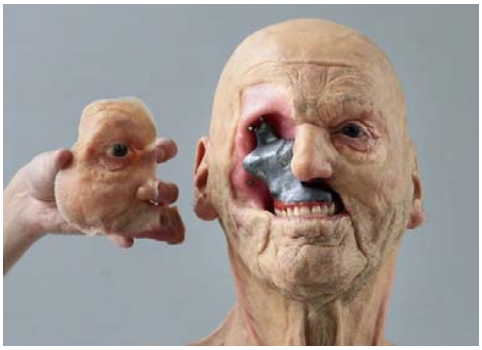

Fig. 1 Human damaged facial scull

Fig. 2 Damaged facial scull replaced by RP model

B. Textile Application

The RP techniques models are widely used in textile industries. The complicated contour profile dresses are designing in the 3D model with aid of computer and directly inter connected with manufacturing machine. Fig. 3 shows the RP model dresses with complicated contours.

Fig. 3 RP model of dresses with special contours

C. Electrical Appliances

The house holding electrical appliances are widely manufactured in the PR techniques. These RP techniques are very useful for manufacturing the special contours in an electrical item. Fig. 4 shows the RP models of electrical appliances.

Fig. 4 RP model of an electrical appliances

D. Foot-Ware Design

The foot-ware for a human comfort is manufacturing in RP technique. This type of foot-ware should have light weight and stronger than the conventional model. And also the complicated design of foot-ware is developed in the RP technique models without any fastener. The reliability of the RP model is very high compared with conventional model. Fig. 5 shows the RP technique developed foot-ware model.

E. Furniture Design

The furniture is designed and manufacturing with a aid of RP techniques. This model has low weight and no temporary and permanent joints. It is made up of a single piece without any joints with different profiles. Fig. 6 shows the furniture model developed in the RP technique.

Fig. 5 RP model of foot-ware

Fig. 6 RP model of furniture

F. Architectural Interior Design

An RP technique plays an important role in architectural interior design like stature, wall mountings and toys. The RP model of interior decoration has good surface finishing and aesthetics compared with convention models. Fig. 7 shows RP models of an architectural interior design.

Fig. 7 RP models of an architectural interior design

G. Design of Special Objects

RP techniques are used for developing some special contours objects like spherical, hemi spherical and tree stems.

This models having a hollow space in the inner side and thickness in the outer shell. This type of objects has developed in the conventional method is so complicated and time consumptions. But in the RP technique it is developed in the shortest time as compared with the conventional method. Figs. 8 (a) and (b) show the RP model of the special objects developed in the RP techniques.

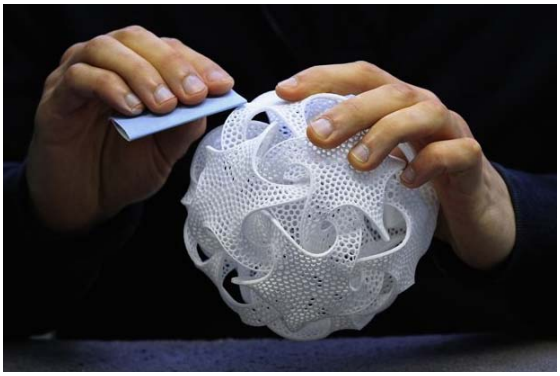

Fig. 8 (a) RP model of special objects (Spherical)

Fig. 8 (b) RP model of special objects (Tree stems)

V. Challenges Associate Insight in Rapid Prototyping

The following are the challenges associate insight in rapid prototyping. The RP models are manufacturing directly from the computer aided design model with automated machine. Hence, the following are to be considered for developing the RP system.

a) Develop automatic recognition of appropriate geometric features from the STL file, such as; minimum wall thickness
b) Develop the rules relating to prototyping metal components.
c) Improve the user definition or classification of prototype use.
d) Investigate which method of delivery best answer the needs of small companies and who would be responsible for its upkeep.
e) Create a full system in a native programming environment suitable for delivery in the manner identified.

VI. Factors to Be Considered While Developing RP Techniques in Indian Scenario

The following are the factors to be considered for developing the RP techniques in Indian scenario.

a) Initial investment Cost
b) Availability of trained people
c) Knowledge in the automatic system
d) Availability of material
e) Programming language
f) Awareness of RP techniques
g) Reality of the model
h) Knowledge in the 3D modeling
i) Selection of Modeling software

VII. Conclusion

RP is one of the fastest growing new technologies of manufacturing the various products by adding the material in layer by layer and directly from the 3D CAD model connected with the automated machine. This paper deals with the various RP model related to the field of applications. This paper provides a platform for researchers, new learners and product manufacturers to create an awareness of rapid prototyping and manufacturing technology for creating the complicated and different contour products in various field of applications. The various points are discussed in this paper for the researchers to insight the challenges associate in rapid prototyping. However, some of the factors are given for developing the RP techniques in Indian scenario.

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